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**Yang et al.**

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(54) **HEAT SINK FOR ELECTRICAL ELEMENTS  
AND LIGHT-EMITTING DEVICE  
CONTAINING THEREOF**

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**F21V 29/85** (2015.01)  
**F21V 29/83** (2015.01)  
**H01L 23/467** (2006.01)  
**H01L 33/64** (2010.01)  
**F21Y 101/02** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **F21V 29/85** (2015.01); **F21V 29/83**  
(2015.01); **H01L 23/467** (2013.01); **H01L**  
**33/648** (2013.01); **F21Y 2101/02** (2013.01);  
**H01L 2924/0002** (2013.01)

(58) **Field of Classification Search**

CPC ..... F28F 3/00; F21V 29/83; F21V 29/85;  
F21Y 2101/02; H01L 23/467; H01L 33/648;  
H01L 2924/0002

See application file for complete search history.

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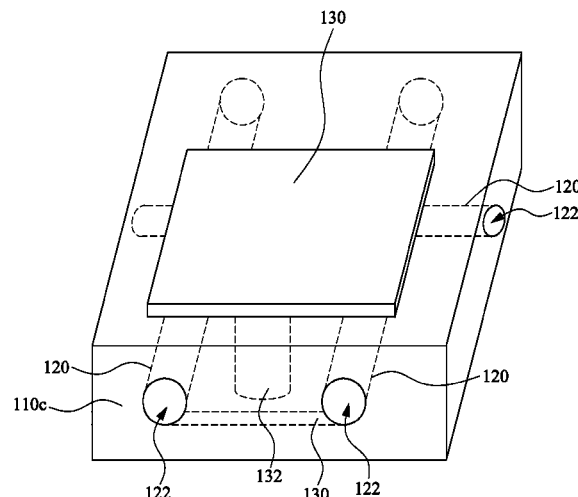
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(57) **ABSTRACT**

The disclosure provides a heat sink for electrical elements and a light-emitting device containing thereof. The heat sink includes a radiating substrate and at least one hollow radiating channel. In which, the hollow radiating channel is horizontally embedded in the radiating substrate, and has two openings disposed on the same site or the opposite sites of the radiating substrate, so that gas may flow in the hollow radiating channel and remove heat of the radiating substrate. And a light-emitting device containing the heat sink is also provided.

**9 Claims, 7 Drawing Sheets**

100c



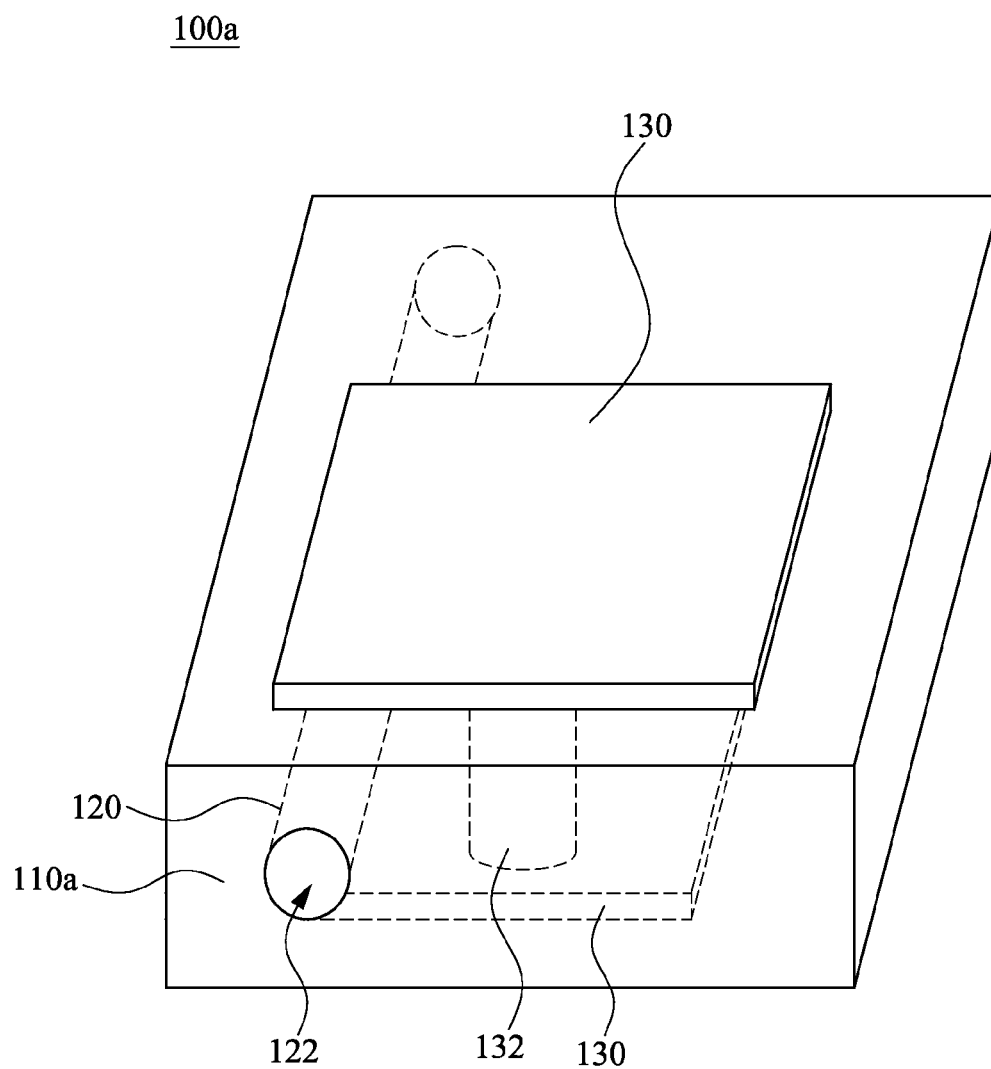


Fig. 1A

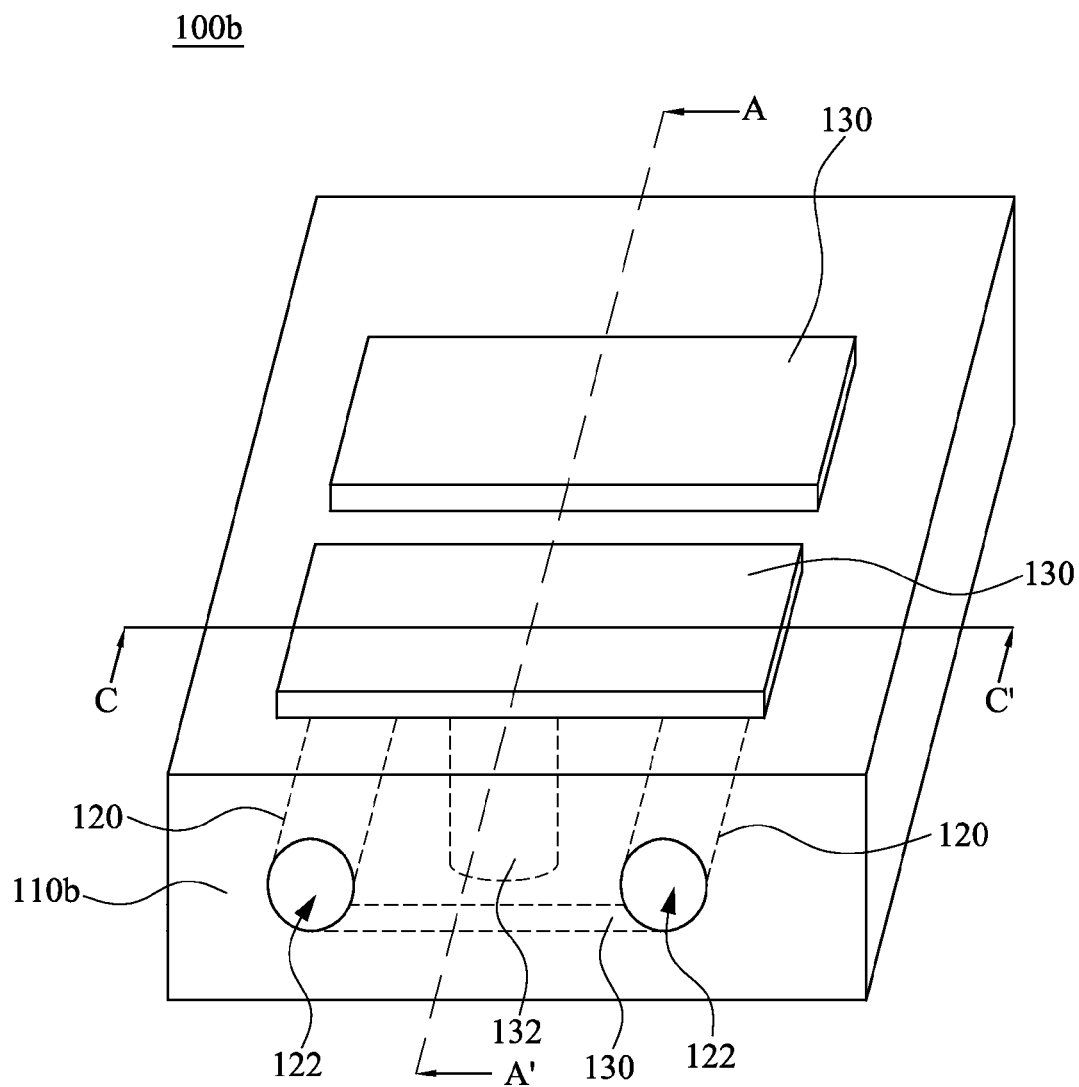


Fig. 1B

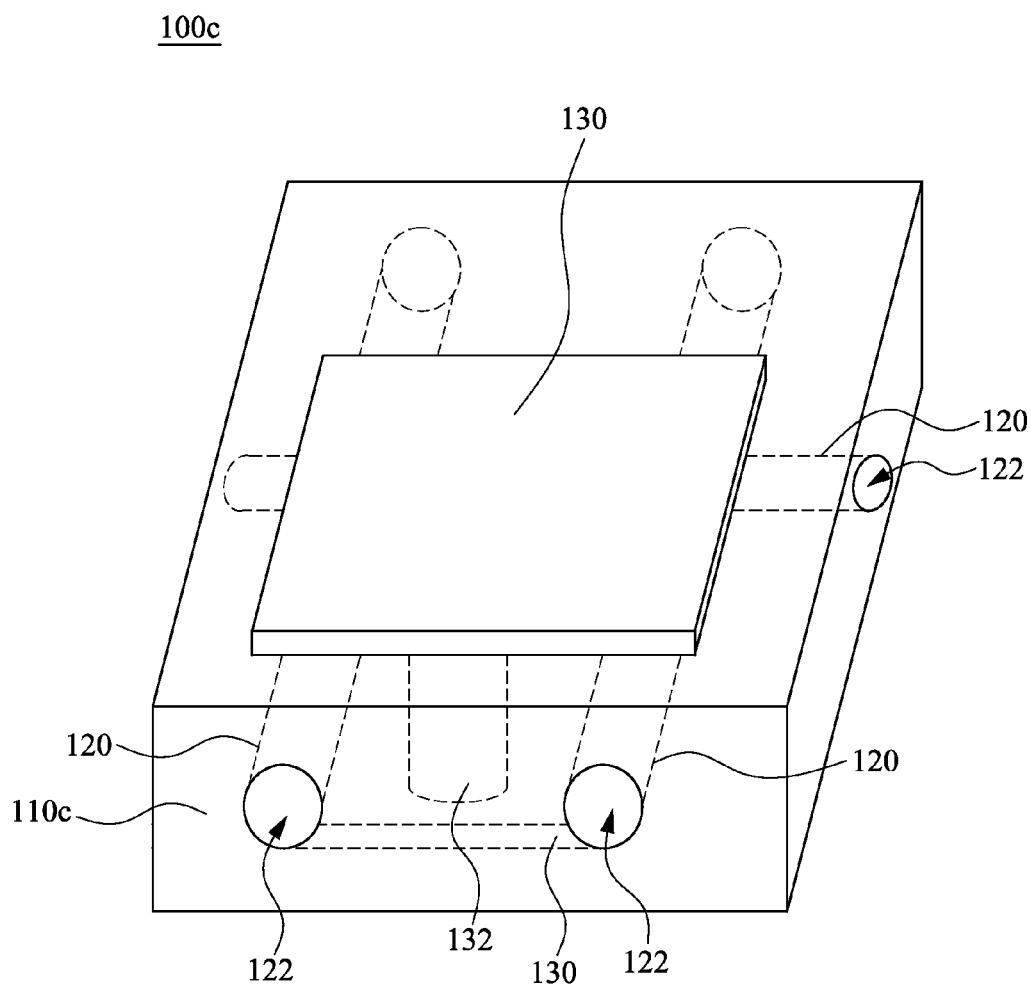


Fig. 1C

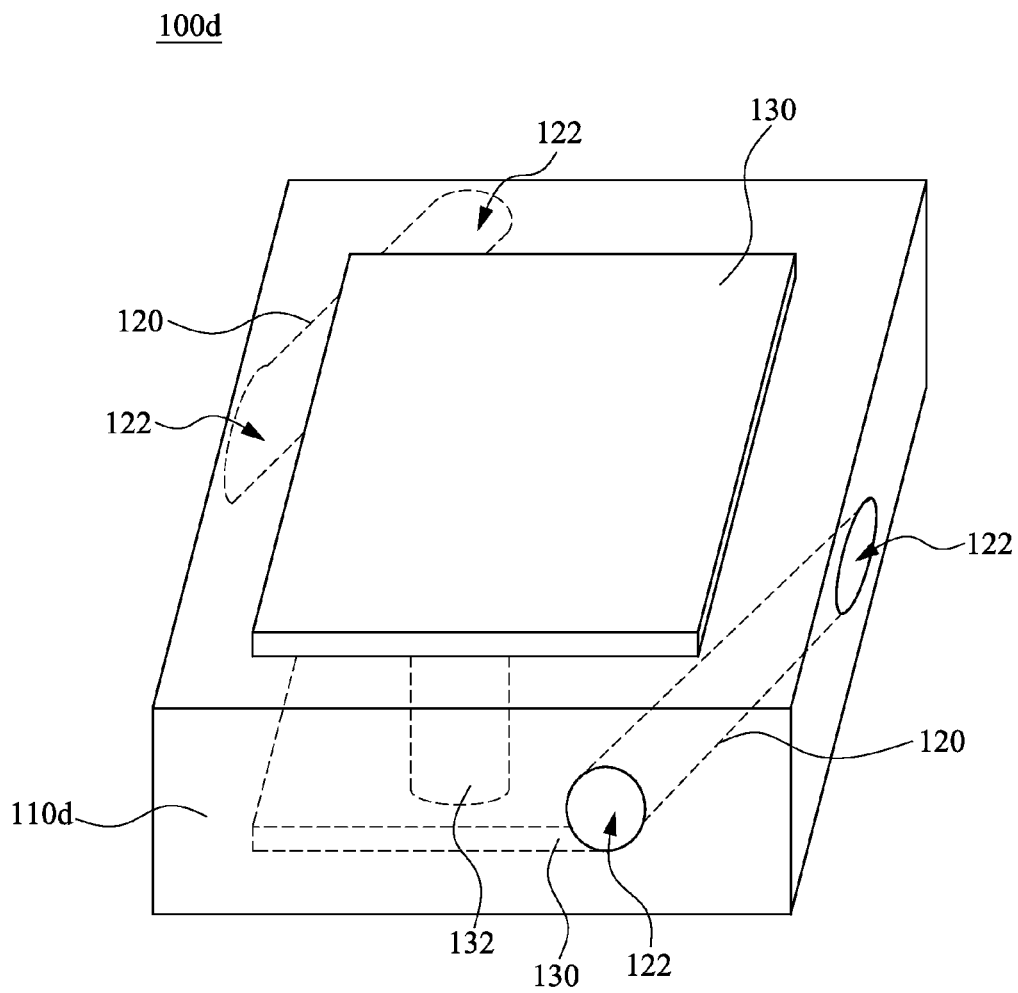


Fig. 1D

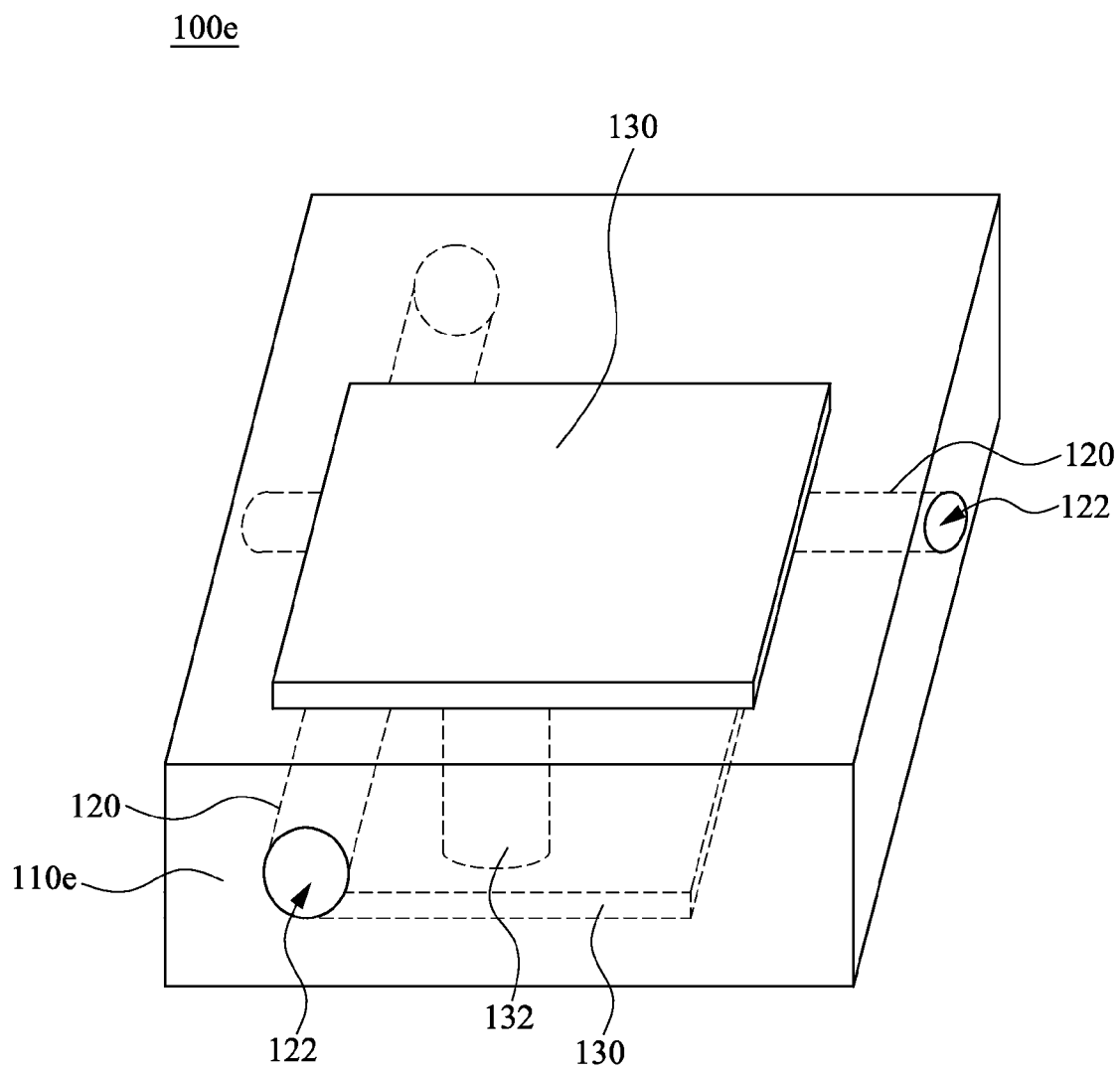


Fig. 1E

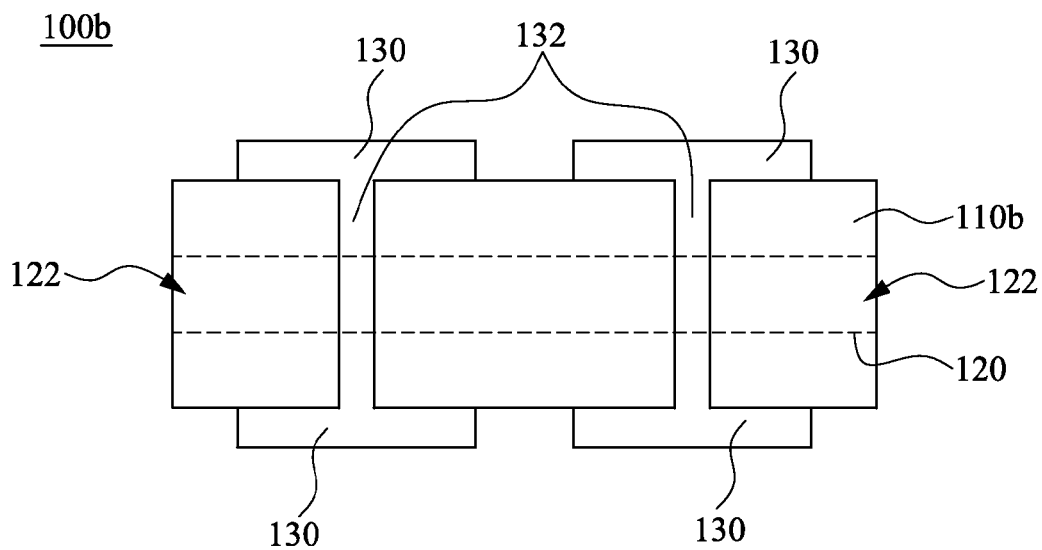


Fig. 2A

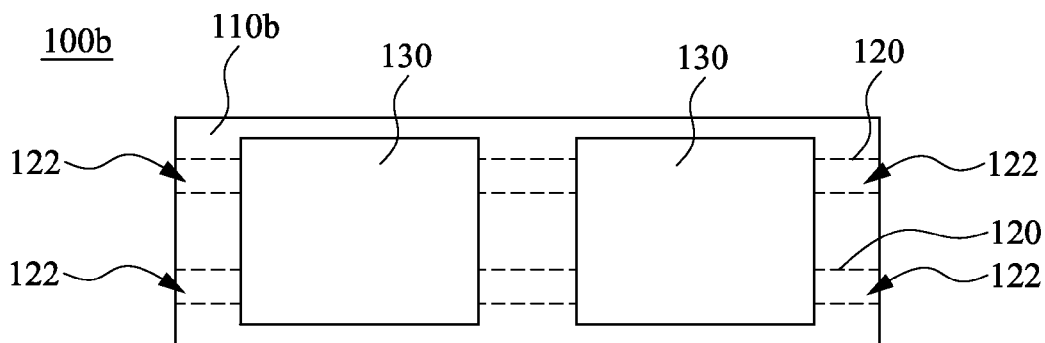


Fig. 2B

100b

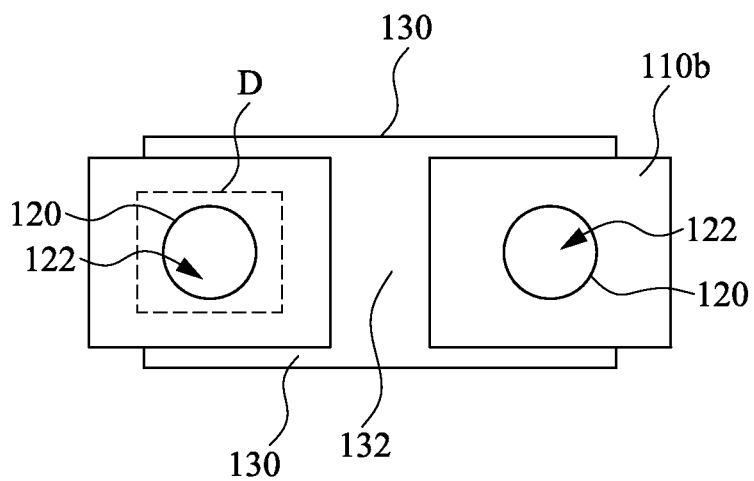


Fig. 2C

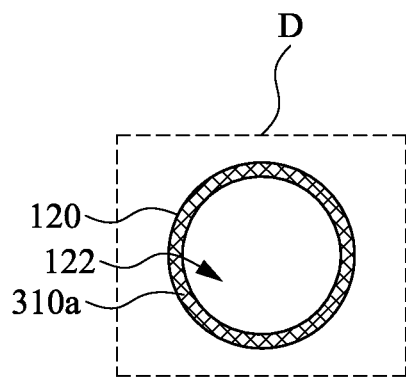


Fig. 3A

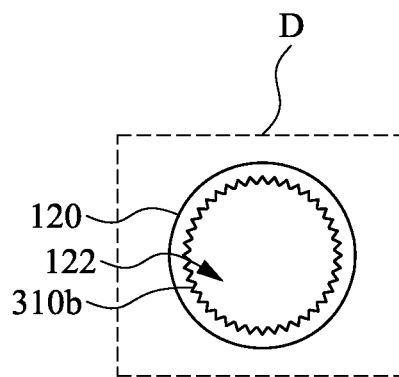


Fig. 3B



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# HEAT SINK FOR ELECTRICAL ELEMENTS AND LIGHT-EMITTING DEVICE CONTAINING THEREOF

## RELATED APPLICATIONS

This application claims priority to Taiwan Application Serial Number 102133408 filed Sep. 14, 2013, which is herein incorporated by reference.

## BACKGROUND

### 1. Technical Field

The present disclosure relates to a heat sink, and more particularly, to a heat sink for electrical elements and a light-emitting device containing thereof.

### 2. Description of Related Art

A general heat sink conducts the heat generated by an electronic device through thermal conductive material making up the heat sink to distribute the heat to a lower temperature portion of the heat sink, and then dissipate the heat into the air by thermal exchange between the air and a surface of the heat sink. In the heat sink, the average temperature of the whole electronic device is commonly decreased by such heat conduction to avoid any thermal damage of the electronic device from overheat.

However, poor thermal conductivity of the heat sink or thermal exchange between the air and the surface of the heat sink may results in heat accumulation in the electronic device which overheats and fails the electronic device.

Therefore, there is a need for an improved heat sink and a light-emitting device containing thereof, so as to solve the aforementioned problems met in the art.

## SUMMARY

The present disclosure provides a heat sink for electrical elements and a light-emitting device containing thereof, to solve the problems met in the art.

One embodiment of the present disclosure is to provide a heat sink for electrical elements. The heat sink comprises a thermal conductive substrate and at least one hollow ventilation channel. The hollow ventilation channel is horizontally embedded in the thermal conductive substrate, and has two openings respectively on the same side or two different sides of the thermal conductive substrate, so that air can flow in the hollow ventilation channel and take away the heat of the thermal conductive substrate.

According to one embodiment of the present disclosure, the heat sink further comprises a composite material layer which is formed on the inner wall of the hollow ventilation channel.

According to one embodiment of the present disclosure, the composite material layer comprises a porous material or a hygroscopic material.

According to one embodiment of the present disclosure, the composite material layer comprises a carbonaceous material, a polymer, a metal oxide or a combination thereof.

According to one embodiment of the present disclosure, the heat sink of further comprises a roughened surface which is formed on the inner wall of the hollow ventilation channel.

According to one embodiment of the present disclosure, the material of the thermal conductive substrate includes ceramics, metals or silicon materials.

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According to one embodiment of the present disclosure, the thermal conductive substrate is a copper substrate or a silicon substrate.

According to one embodiment of the present disclosure, the two different sides of the thermal conductive substrate are two opposite sides or two adjacent sides.

Another embodiment of the present disclosure is to provide a light-emitting device. The light-emitting device comprises the aforementioned heat sink and at least one light-emitting element positioned on the heat sink.

According to one embodiment of the present disclosure, the light-emitting element is a light-emitting diode.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. 1A is a three-dimensional view of a heat sink **100a** according to one embodiment of the present disclosure;

FIG. 1B is a three-dimensional view of a heat sink **100b** according to one embodiment of the present disclosure;

FIG. 1C is a three-dimensional view of a heat sink **100c** according to one embodiment of the present disclosure;

FIG. 1D is a three-dimensional view of a heat sink **100d** according to one embodiment of the present disclosure;

FIG. 1E is a three-dimensional view of a heat sink **100e** according to one embodiment of the present disclosure;

FIG. 2A is a schematic cross-sectional view of the heat sink **100b** taken along the line A-A' of FIG. 1B;

FIG. 2B is the top view of the heat sink **100b** of FIG. 2A;

FIG. 2C is a schematic cross-sectional view of the heat sink **100b** taken along the line C-C' of FIG. 1B;

FIG. 3A is an enlarged view of a hollow ventilation channel **120** of the region D in FIG. 2C; and

FIG. 3B is an enlarged view of a hollow ventilation channel **120** of the region D in FIG. 2C.

## DETAILED DESCRIPTION

The embodiments of the transparent conductive structure and a method for manufacturing the same of the present disclosure are discussed in detail below, but not limited the scope of the present disclosure. The same symbols or numbers are used to the same or similar portion in the drawings or the description. And the applications of the present disclosure are not limited by the following embodiments and examples which the person in the art can apply in the related field.

The singular forms “a,” “an” and “the” used herein include plural referents unless the context clearly dictates otherwise. Therefore, reference to, for example, a metal layer includes embodiments having two or more such metal layers, unless the context clearly indicates otherwise. Reference throughout this specification to “one embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Therefore, the appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Further, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. It should be appreciated that the following figures are not drawn to scale; rather, the figures are intended; rather, these figures are intended for illustration.

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FIG. 1A is a three-dimensional view of a heat sink **100a** according to one embodiment of the present disclosure. In FIG. 1A, the heat sink **100a** comprises a thermal conductive substrate **110a** and a hollow ventilation channel **120** horizontally positioned in the thermal conductive substrate **110a**. The hollow ventilation channel **120** has two openings **122**, and the two openings **122** are respectively on two different sides of the thermal substrate **110a**. Therefore, air may flow in the hollow ventilation channel **120** and take away the heat of the thermal conductive substrate **110a**.

In FIG. 1A, the two openings **122** of the hollow ventilation channel **120** are respectively on the opposite sides of the thermal conductive substrate **110a**. The top surface and the bottom surface of the thermal conductive substrate may further comprise a plurality of metal electrodes and a plurality of conductive pillars electrically connected to the metal electrodes. In one embodiment of the present disclosure, the top surface and the bottom surface of the thermal conductive substrate **110a** respectively have metal electrodes **130**, and the metal electrodes **130** are electrically connected by a conductive pillar **132**, as shown in FIG. 1A.

According to one embodiment of the present disclosure, the material of the thermal conductive substrate includes ceramics, metals or silicon materials. According to another embodiment of the present disclosure, the thermal conductive substrate is a copper substrate or a silicon substrate.

FIG. 1B is a three-dimensional view of a heat sink **100b** according to one embodiment of the present disclosure. In FIG. 1B, the heat sink **100b** comprises a thermal conductive substrate **110b** and two hollow ventilation channels **120** parallel to each other and horizontally positioned in the thermal conductive substrate **110b**. Each one of the hollow ventilation channels **120** has two openings **122**, and the two openings **122** are respectively on opposite sides of the thermal substrate **110b**. Therefore, air may flow in the hollow ventilation channels **120** and take away the heat of the thermal conductive substrate **110b**. In one embodiment of the present disclosure, the heat sink has a thermal conductive substrate and a U-shaped hollow ventilation channel, wherein the U-shaped hollow ventilation channel has two openings on the same side of the thermal conductive substrate.

Further, in one embodiment of the present disclosure, the top surface and the bottom surface of the thermal conductive substrate **110b** respectively have metal electrodes **130**, and the metal electrodes **130** are electrically connected by a conductive pillar **132**, as shown in FIG. 1B. In one embodiment of the present disclosure, a light-emitting device comprises a heat sink and at least one light-emitting element on the heat sink. In one embodiment of the present disclosure, the light-emitting element may be bonded on the thermal conductive substrate and electrically connected to the metal electrode. In which, the light-emitting element may be a light-emitting diode.

FIG. 1C is a three-dimensional view of a heat sink **100c** according to one embodiment of the present disclosure. In FIG. 1C, the heat sink **100c** comprises a thermal conductive substrate **110c** and three hollow ventilation channels **120** horizontally positioned in the thermal conductive substrate **110c**. Each one of the hollow ventilation channels **120** has two openings **122**, and the two openings **122** are respectively on opposite sides of the thermal substrate **110c**. Therefore, air may flow in the hollow ventilation channels **120** and take away the heat of the thermal conductive substrate **110c**.

In FIG. 1C, two of the hollow ventilation channels **120** are parallel to each other, and the other hollow ventilation channel **120** is crisscrossed to the two hollow ventilation

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channels **120**, so as to increase the opportunity and direction of air flow. Further, in one embodiment of the present disclosure, the top surface and the bottom surface of the thermal conductive substrate **110c** respectively have metal electrodes **130**, and the metal electrodes **130** are electrically connected by a conductive pillar **132**, as shown in FIG. 1C.

FIG. 1D is a three-dimensional view of a heat sink **100d** according to one embodiment of the present disclosure. In FIG. 1D, the heat sink **100d** comprises a thermal conductive substrate **110d** and two hollow ventilation channels **120** horizontally positioned in the thermal conductive substrate **110d**. Each one of the hollow ventilation channels **120** has two openings **122**, and the two openings **122** are respectively on opposite sides of the thermal substrate **110d**. Therefore, air may flow in the hollow ventilation channels **120** and take away the heat of the thermal conductive substrate **110d**.

Different from FIG. 1B, the hollow ventilation channels **120** in FIG. 1D are positioned on a slant in the thermal conductive substrate **110d**, thus the two openings **122** of the hollow ventilation channels **120** are on the adjacent sides of the thermal conductive substrate **110d**. Further, in one embodiment of the present disclosure, the top surface and the bottom surface of the thermal conductive substrate **110d** respectively have metal electrodes **130**, and the metal electrodes **130** are electrically connected by a conductive pillar **132**, as shown in FIG. 1D.

FIG. 1E is a three-dimensional view of a heat sink **100e** according to one embodiment of the present disclosure. In FIG. 1E, the heat sink **100e** comprises a thermal conductive substrate **110e** and two hollow ventilation channels **120** horizontally positioned in the thermal conductive substrate **110e**. Each one of the hollow ventilation channels **120** has two openings **122**, and the two openings **122** are respectively on opposite sides of the thermal substrate **110e**. Therefore, air may flow in the hollow ventilation channels **120** and take away the heat of the thermal conductive substrate **110e**.

In FIG. 1E, the two hollow ventilation channels **120** are crisscrossed to each other to increase the opportunity and direction of air flow. Further, in one embodiment of the present disclosure, the top surface and the bottom surface of the thermal conductive substrate **110e** respectively have metal electrodes **130**, and the metal electrodes **130** are electrically connected by a conductive pillar **132**, as shown in FIG. 1E.

FIG. 2A is a schematic cross-sectional view of the heat sink **100b** taken along the line A-A' of FIG. 1B. In FIG. 2A, the hollow ventilation channels **120** are horizontally positioned in the thermal conductive substrate **110b**, having two openings **122** respectively on opposite sides of the thermal substrate **110b**. Further, the metal electrodes **130** are individually positioned on the top surface and the bottom surface of the heat sink **100b**. In which, a metal electrode **130** on the top surface and a metal electrode **130** on the bottom surface may pair up and be electrically connected by a conductive pillar **132**.

FIG. 2B is the top view of the heat sink **100b** of FIG. 2B. In FIG. 2B, the two hollow ventilation channels **120** are parallel to each other and positioned in the thermal conductive substrate **110b**. Each one of the hollow ventilation channels **120** has two openings **122** respectively on opposite sides of the thermal conductive substrate **110b**. In one embodiment of the present disclosure, the hollow ventilation channels **120** are under the metal electrodes **130**, so as to fully absorb the heat generated by electronic elements to enhance the ventilation performance.

FIG. 2C is a schematic cross-sectional view of the heat sink **100b** taken along the line C-C' of FIG. 1B. In FIG. 2C,

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the hollow ventilation channels **120** are under the metal electrodes **130**, so as to fully absorb the heat generated by electronic elements to enhance the ventilation performance. Further, the metal electrodes **130** are individually positioned on the top surface and the bottom surface of the heat sink **100b**. In which, a metal electrode **130** on the top surface and a metal electrode **130** on the bottom surface may pair up and be electrically connected by a conductive pillar **132**.

FIG. **3A** is an enlarged view of a hollow ventilation channel **120** of the region D in FIG. **2C**. In FIG. **3A**, the inner wall of the hollow ventilation channels **120** further comprises a composite material layer **310a**. In one embodiment of the present disclosure, the composite material layer **310a** comprises a porous material or a hygroscopic material.

The porous material has greater specific area which may significantly enhance the heat exchanging efficiency between the heat sink and air, so as to increase the ventilation performance. On another way, when the hygroscopic material is used to absorb water vapor in air, the temperature of the heat sink may change gradually because of the high specific heat of water. Further, water has higher heat of evaporation, so that the heat of the heat sink may be more absorbed as evaporation of water. In one embodiment of the present disclosure, the composite material layer **310a** includes a carbonaceous material, a polymer, a metal oxide or a combination thereof.

FIG. **3B** is an enlarged view of a hollow ventilation channel **120** of the region D in FIG. **2C**. In FIG. **3B**, the inner wall of the hollow ventilation channels **120** further comprises a roughened surface **310b**. The inner wall of the hollow ventilation channel **120** is roughened by a roughening process to generate a roughened surface **310b**. Compared with a smooth surface, the roughened surface has a greater specific area which may increase the heat exchanging efficiency between the heat sink and air and enhance the performance of ventilation.

In embodiments of the present disclosure, the heat sink has at least one hollow ventilation channel which may significantly enhance the heat exchanging efficiency between the heat sink and air, so as to increase the ventilation performance. Further, the hollow ventilation channel is horizontally positioned in the thermal conductive substrate, and has exposed openings keeping the air in circulation.

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Although embodiments of the present disclosure and their advantages have been described in detail, they are not used to limit the present disclosure. It should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the present disclosure. Therefore, the protecting scope of the present disclosure should be defined as the following claims.

What is claimed is:

1. A heat sink for electrical elements, comprising:
  - a thermal conductive substrate; and
  - at least one hollow ventilation channel horizontally embedded in the thermal conductive substrate, the hollow ventilation channel having a roughened surface formed on the inner wall of the hollow ventilation channel and two openings respectively on the same side or two different sides of the thermal conductive substrate, so as to flow air in the hollow ventilation channel and take away the heat of the thermal conductive substrate.
2. The heat sink of claim 1, further comprising a composite material layer formed on the inner wall of the hollow ventilation channel.
3. The heat sink of claim 2, wherein the composite material layer comprises a porous material or a hygroscopic material.
4. The heat sink of claim 3, wherein the composite material layer comprises a carbonaceous material, a polymer, a metal oxide or a combination thereof.
5. The heat sink of claim 1, wherein the material of the thermal conductive substrate includes ceramics, metals or silicon materials.
6. The heat sink of claim 5, wherein the thermal conductive substrate is a copper substrate or a silicon substrate.
7. The heat sink of claim 1, wherein the two different sides of the thermal conductive substrate are two opposite sides or two adjacent sides.
8. A light-emitting device, comprising:
  - the heat sink of claim 1; and
  - at least one light-emitting element positioned on the heat sink.
9. The light-emitting device of claim 8, wherein the light-emitting element is a light-emitting diode.

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